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ARE THERE PERIODS IN AMERICAN BUSINESS ACTIVITY?*

By Professor EDWIN B. WILSON

HARVARD SCHOOL OF PUBLIC HEALTH

WHEN I was spending a pleasant and instructive semester here in Berkeley five years ago, one of the talks I gave was on rainfall in Boston from the forty-year record of the Blue Hill Observatory of Harvard University. I showed that dry months had not followed dry months any more or any less than heads follow heads in tossing a coin. This may not seem a very satisfactory result of a considerable statistical study, but it is one of the especial functions of the statistician to discuss precisely this point, *viz.*, as to whether the behavior of phenomena is no more than might be expected of a chance series. We must remember that chance refers to the future, to the unknown. If we toss a fair coin fairly there is before each throw an equal chance of heads or tails. After the throw has been made and the result has been observed there is not chance but certainty as to what did happen. There are all too many persons who have a feeling that if throws of a coin have been running to heads, they will continue to run to heads and altogether too many who contrariwise have the feeling that if the throws have been running to heads they must tend to change and run to tails to even the series up. Neither of these feelings is correct; the chance of the next throw coming heads or tails is even and independent of the results of previous throws—always assuming that we are dealing with a fair coin

*Address before a general session of the American Association for the Advancement of Science, given at the University of California, June 21, 1934.

fairly thrown. If, therefore, one can demonstrate that the runs of wet or dry months in the vicinity of Boston are as runs of heads or tails at coin throwing one has learned something rather definite which will tend to show that he can not predict the unknown result in the next month from the known results of previous months. Of course the statistician always hopes that he will find that the phenomenon does not behave entirely as though it were a chance series so that he may have some lawful residue in the behavior of the phenomenon which will enable him to forecast successfully to some extent; he hopes in other words to obtain some control over knowledge as to what the future will bring forth, even though he may be unable to prevent untoward or to facilitate favorable happenings. And of course he hopes that he may further learn enough to enable him to exercise an actual control over future happenings.

I should like here to interject the remark that our actual control over the future is much less than many persons believe, even in the field of natural science. We have as yet no means of controlling the weather, we can not control the tides, we can not control eclipses, despite the perfection of astronomical forecasts based on the analysis of periods. In many fields the knowledge of the future is as yet serviceable to us in the way of control only to the extent of permitting us to control our own conduct so as to take advantage of or so as to avoid the disadvantages incident to the phenomena which we forecast. The important rôle of self-control, of self-adjustment to what will, or even to what may, happen should not be overlooked; it is likely to be overlooked and I think there are many evidences that it has been overlooked.

The tides are predicted to a considerable degree of accuracy by their analysis into periodic elements. If we could equally well analyze the tides of business activity into periodic elements we might be able to foretell the future well enough to enable us better to adjust ourselves to the coming fluctuations, even if we could do nothing to influence them, as we can not in the case of the tides. Of course, although adjustments to the ebb and flow of the marine tides does not in any way affect those tides, it is probable that any knowledge of the future ebb and flow of business which would be adequate to be of substantial avail as an aid in our adjustment to it would as a matter of fact modify the business tide.[1] There may be this real complication in the social forecasting, *viz.*, that possibly a knowledge of the future if we could gain it from the study of the past would so modify that future that we could not hope to forecast it without taking into account the degree to which such knowledge as we had of it would influence its course—all of which sounds like an Irish bull, but only means that social phenomena may have to be treated by the as yet poorly developed methods of differentio-integral equations.

That of which I wish to speak to-night is a statistical analysis we have made[2] to ascertain whether there are periods in American business activity, as there certainly are in the tides. The method used is that of periodogram analysis developed 30 or 40 years ago by Sir Arthur Schuster to discuss the problem of periods in meteorological or astronomical phenomena such as those of sunspots or terrestrial magnetic storms. One may show that if there were in a long series of data a period which was not disturbed by interference with other nearby periods or by fortuitous fluctuations, one could by a certain mathematical calculation compute from the data a curve called the periodogram with a pronounced peak indicative of that period. The converse is unfortunately not true, namely, if by that computation one finds a periodogram with a peak there may be in the phenomenon no corresponding simple period of the tidal type. The difficulty is that the theory of the periodogram presupposes a long series of data, long enough to permit the disturbances due to accidental fluctuations to balance each other out, long enough to enable nearby periods to be distinctly separated from one another, long enough to permit the subdivision of the series to test the subdivisions for periods—and in a practical case the series though long may not be long enough. As a matter of fact we have shown that the longest index of business activity which we have (that of Leonard Ayres[3] running by months back to 1790) is too short to give satisfactory results. When the periodogram for this index of business activity was constructed it appeared that there were peaks in the curve suggestive of periods in business, but that these peaks were not in the same places for the whole data and for different 70-year sections of the data, indicating that at best there might be no sufficient definiteness and constancy of the periods to make them useful for forecasting.[4]

[1] I recall that when a prominent New York banker was introducing Leonard Ayres some years ago he commented on the remarkable way Ayres had forecast the top of the bond market several months in advance, but added that if his bank had believed that forecast the top would have come earlier because of the effect of their selling of bonds in anticipation of the culmination of the rise.

[2] The Periodogram of American Business Activity, *Quarterly Journal of Economics*, May, 1934, pp. 375–417, prepared with major assistance of Miss Margaret Hilferty and Miss Jane Worcester. The editor of the journal has kindly permitted the use of such material from the paper as I need for my present purposes.

[3] The index was published by the Cleveland Trust Company under date of August, 1931.

[4] For the details it is necessary to refer to our complete article; intricate matters of the sort here under consideration can at best merely be adumbrated in a summary.

The statistician, however, has always one primary question to solve, as has been mentioned, namely, whether the phenomenon might after all be irregular as though due to chance. Now one of the real contributions of Sir Arthur Schuster in his famous papers was a test to determine whether the fluctuations in a series were or were not chance fluctuations. To apply the test it is necessary to have the periodogram. If then one finds the result that the oscillations of the series are fluctuations, one should refrain from interpreting the peaks as indications of true periodicities. When this test of Schuster's was applied, we found that it showed that the oscillations of Ayres' Index of American Business Activity were essentially fortuitous. Schuster's test has, however, been called in question by other investigations of fluctuating phenomena and has been replaced by one which when applied to our case would indicate that the fluctuations were not fortuitous but probably contained periods. Thus the inference we should draw must depend on whether we accept Schuster's test or that of his critics.

The question, therefore, becomes one of decision between two scientific propositions. How is such a decision made? When the matter is essentially one of mathematics or of logic as in the case of these tests, it may be possible to make a decision between two opposing propositions by a critical logical or mathematical analysis of the proof of the propositions. Theoretically, it should always be possible to make the decision in this way—either the one or the other party has obtained an incorrect test, the reasoning of one or the other or of both has been in some respect incorrect. Practically, however, it is often impossible to detect the error in an erroneous line of argument and appeal has to be made to experiment as it has always to be made in those cases when the opposing criteria are not strictly mathematical or logical. We therefore proceeded experimentally. We noted that during the 140 years from 1790 to 1929, the index had 42 complete swings from normal to high to normal to low and back to normal, or, if you prefer, 42 swings from top to top—it makes little difference at what phase of the oscillation one considers that the fluctuation begins. It was found that the duration of a complete swing was on the average about 40 months but that the duration varied from a few months to eight years (Fig. 1, left). It was found, also, that the magnitude of the swing averaged 20 per cent., but varied from practically nothing to about 45 per cent. (Fig. 1, right). (In the current swing, which is not yet complete, the oscillation has been greater than 45 per cent.; what the duration may prove to be no one knows, but it has not yet reached that of previous long swings.) We then took these

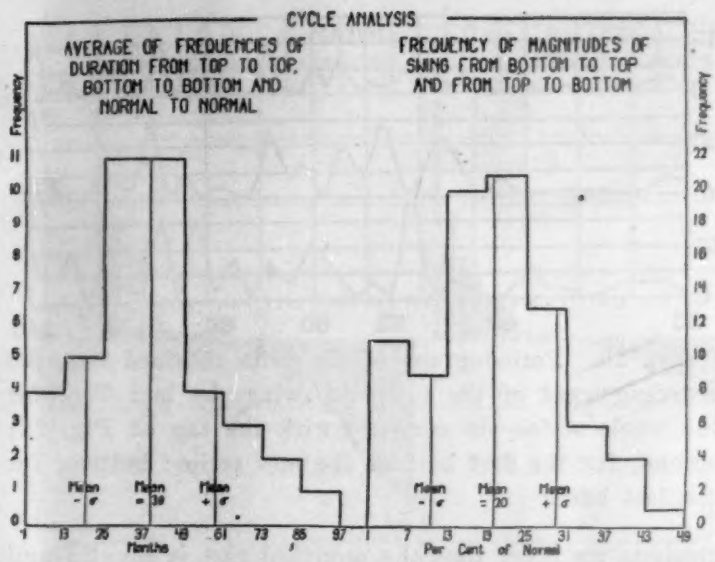

FIG. 1. The histograms or frequency distributions of (1) durations of complete swings (left, with duration in months as abscissas and frequency as ordinates) and of (2) magnitude of swings (right, with magnitude as abscissas and frequencies as ordinates, the magnitudes being figured from top to bottom and from bottom to top so that there are two magnitudes for each complete swing). The horizontal scales have been chosen so that the standard deviations are the same. The frequency distributions are not too dissimilar, but the correlation between the individual durations and magnitudes is not large.

42 swings as units, drew them serially by lot and pieced them together into a new artificial index to which we applied an analysis similar to that which we had applied to Ayres' index and with very similar results; the new periodograms looked like the old ones (Fig. 2, a, b), and like them they showed no signifi-

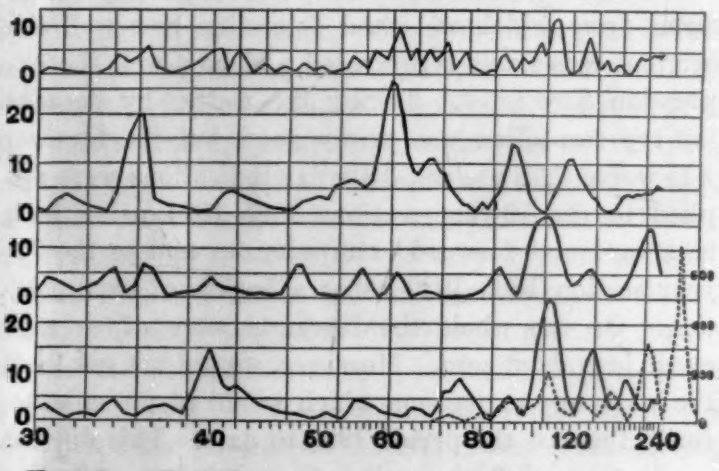

FIG. 2a. Periodograms of Ayres's Index: Top, for the whole series, 1790–1929; second, for 1790–1859; third, for 1825–1894; bottom, for 1860–1929. (The dotted curve at the bottom may be ignored.)

cant periods by Schuster's test but significant periods by the modification which has been proposed for testing significance. As it is difficult to believe that a random rearrangement of the swings could have

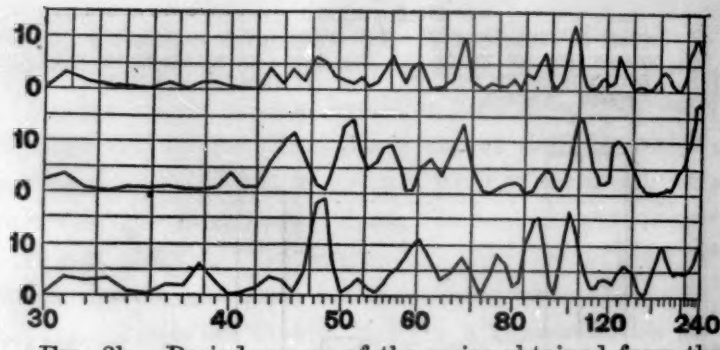

FIG. 2b. Periodograms of the series obtained from the rearrangement of the complete swings by lot: Top, for the whole series—to compare with the top of Fig. 2a; second, for the first half of the new series; bottom, for the last half.

periods we infer that the modified test is invalid and as the periodograms behave similarly with respect to the tests we infer that there is no more and no less periodicity in Ayres' Index of American Business Activity than there is in a random rearrangement of its component individual full swings.

Such an inference would imply that we could hardly expect to forecast as we do in the case of the tides by resolving the index into periodic terms and using those terms for purposes of extrapolation. But we could try the method, unpromising though it seemed, and this was done. Of course one must not depend on any single instance of forecasting, because one might have an accidental agreement or disagreement between forecast and realization which would be unduly favorable or unfavorable. We had three periodograms for three different 70-year sections of the data. From the indications of periods such as they were in the analysis of the data from 1790 to 1859 we constructed an expression made up of periodic terms from which we could determine how well the original series was represented and how well the expression forecasted. Taking the matter by decades the representation was pretty good, but the forecast was worse than useless. Similar indications were applied to the 70-year sections 1825–1894 using both backward and forward extrapolations and to the 70-year section 1860–1929 using a backward extrapolation. On the whole the forecasts were of average merit just about zero. Moreover, we did not get from the work any expression which would at all satisfactorily forecast the period 1930 to date. This did but confirm our inference that there were no effective periods in American business activity.

Such a conclusion is not dissimilar, so far as it goes, to that recently stated by Alter[5] as a result of long-continued analysis of data on English rainfall, namely (1) periodic terms do not exist, (2) nothing has been found to give long-range predictions a commercial value. This does not mean that other methods of analysis which may sometime be discovered must also fail to give long-range predictions of value for English rainfall or for American business activity. For example, some time ago Mr. Moe, of the Guggenheim Foundation, sent a young Argentinian Mr. Mata to see me. Mata believes that business activity is a correlate of solar activity and with a good deal of ingenuity he has established some rather high correlations between past records of these two types of fluctuating phenomena. I have said that we wish to resolve phenomena into periods to help us predict, but if we have two phenomena, say B for business activity and S for solar activity, and if the pattern of the fluctuations of the two are very much alike, but B follows S in time with a certain lag, then clearly we could predict B from S by the extent of that lag.

Now by whatever means one produces predictions, whether by resolution into periods or by correlation with a phenomenon which runs ahead of the one predicted, or by the exercise of general judgment, or by crystal gazing or incantation, there is one thing which the statistician may do—he may take the predictions themselves, provided they are not so oracular that they mean nothing definite, and he may seek to determine whether the predictions have in fact predicted any better than by chance. When I was president of the American Statistical Association, I was successful in persuading S. L. Andrew and H. M. Flinn, of the American Telephone and Telegraph Company, to prepare on rather short notice a paper appraising economic forecasts. The results of their statistical examination of the correspondence between forecast and fulfilment for a number of forecasting services showed that during the period 1924–1929 there had been a considerable degree of success in professional forecasts of general business, of commodity prices, of money rates, of automobile production and of construction, but no success at all in forecasting stock prices; indeed, stock price forecasts were more often wrong than right[6] (Fig. 3). The period 1924–1929 was short and perhaps an easy one in which to forecast general business or commodity prices or money rates, and possibly a more than ordinarily difficult one in which to forecast stock prices. Messrs. Andrew and Flinn did themselves feel that a more careful examination of a longer record of forecasting was desirable before one could come to sound statistical conclusions on the matter of forecasting. So far as forecasts of stock prices are concerned the matter has recently been examined intensively by Alfred Cowles 3rd in the official journal of the Econometric

[5] *Monthly Weather Review*, 61: pp. 345–350, December, 1933.

[6] *Jour. Amer. Statist. Assoc.*, 25: 169A, pp. 36–41, March, 1930. The figure is reproduced by kind permission of Mr. Andrew and of the editor of the journal.

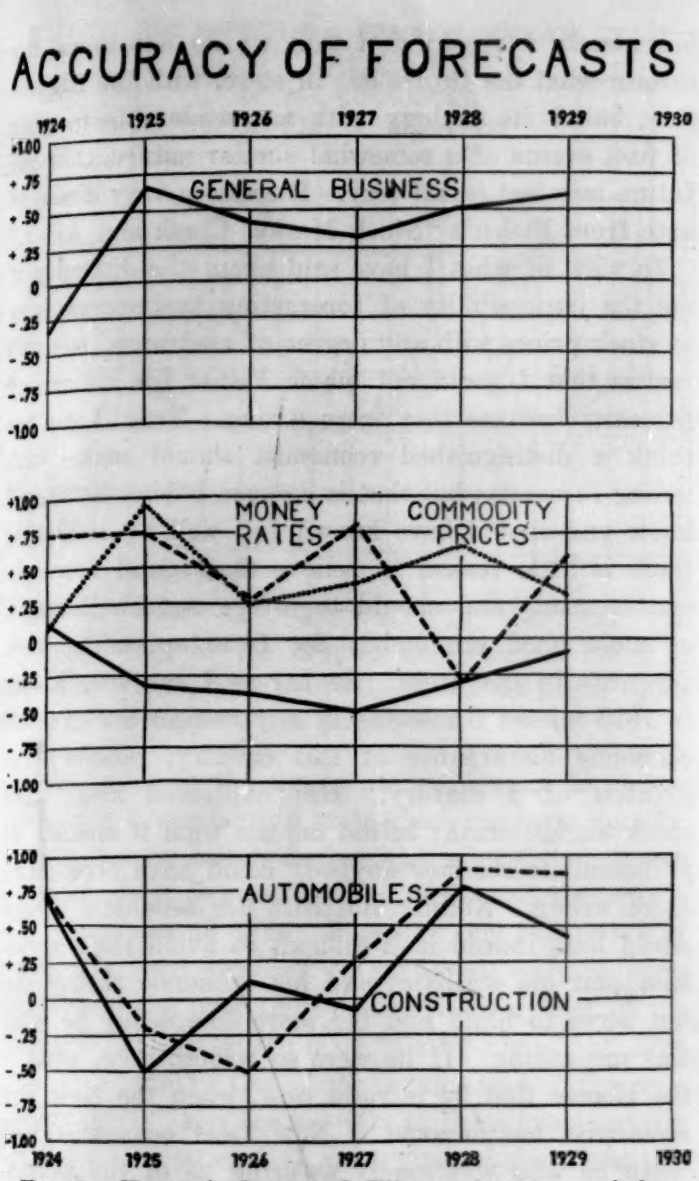

FIG. 3. From Andrew and Flinn. Accuracy of forecast. On the scale 1.00 represents complete accuracy and -1.00 complete incorrectness.

Society, which is meeting here with us.[7] His conclusion is that the forecasts are not so good as random guesswork, thus confirming the conclusion of Andrew and Flinn (Fig. 4). Indeed, he finds that the best forecasts are no better than should be expected in a series of forecasts by guesswork and that the worst forecasts are decidedly worse than those in a set of random records.

Just how bad forecasts of stock prices may be at times can perhaps best be seen by consulting the record of Irving Fisher. Here is a person of the very highest rating as a theoretical economist and of no mean competency in statistical technique, who at about the time I was here five years ago was running a syndicated financial column in the newspapers. He was then one of the New Era economists and there are some indications that he is now a New Deal economist. If you can be amused by tragedy, you would take pleasure in skimming through the compilation of

[7] *Econometrica*, 1: pp. 309–324, 1933. Mr. Cowles has kindly given me permission to reproduce his Figure 1.

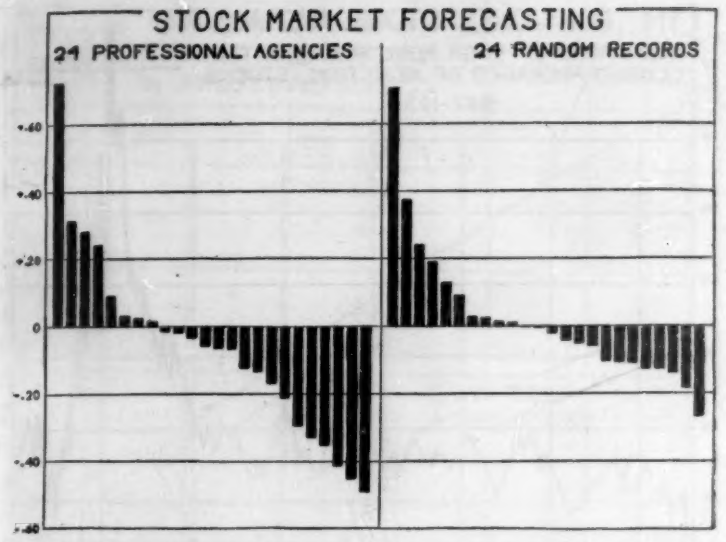

FIG. 4. Comparison of the percentage accuracy in stock market forecasting of 24 Professional Agencies and 24 Random Records (after Cowles). Note that the best records of the forecasters are no better and that the worst records are worse than for the chance series.

Stewart Angly entitled "Oh Yeah?" published by the Viking Press in 1932. But I shall not quote Fisher or others from this compilation of statements appearing in the press. It is not necessary. Fisher wrote a book entitled the "Stock Market Crash and After," published by Macmillan in 1930. The main thesis of this book appears to me to be that the New Era is still with us, that the crash in the autumn of 1929 was to be sure more serious than he had expected, but that it was to a large extent accidental, and that the new high 1926–1929 plateau of stock prices of which he had spoken would not be broken and that we were heading toward a mild boom. As a matter of fact we all know now that nothing could have been wider of the mark. We were facing a disastrous world depression, and stock prices were not on the new high plateau but on a toboggan destined to reach quotations approximately as low as any in the last 40 years (Fig. 5). Indeed, what Fisher meant by using the word plateau in the phrase "the 1926–1929 plateau of stock prices" is very difficult to imagine; the charted course of the market from 1897–1929 should seem to give the impression that the 1926–1929 period constituted a steep mountain side rather than a tableland—whether the abrupt climb was a transition from an old low level to a new markedly higher level or whether it was merely one side of a sierra which when crossed would bring us back to essentially the old level was the problem of the forecaster.

In his book Fisher remarks that "hindsight" is always clearer than foresight. I fail to see that his hindsight as shown in the book is any clearer than his foresight as expressed in his earlier newspaper items. Quite the contrary, it seems to me that the explanations offered by this "clearer" hindsight are largely

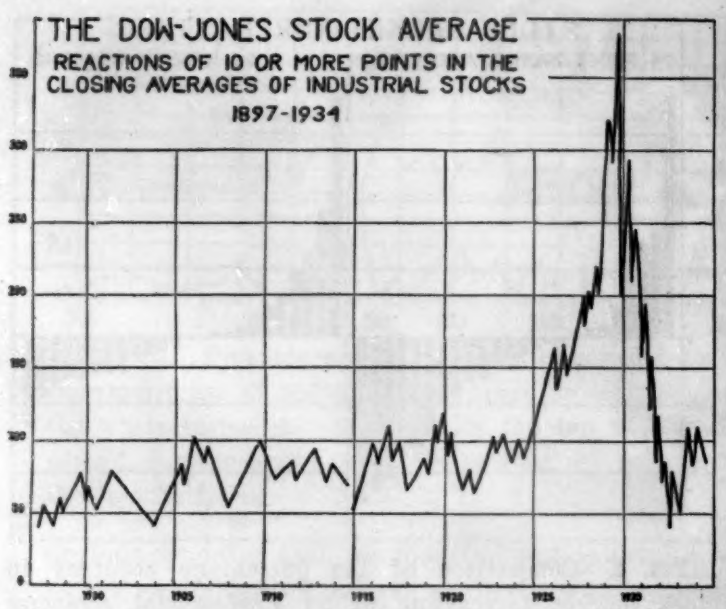

FIG. 5. The Dow-Jones Industrial Average 1897–1934. Note that this average returned in 1932 to approximately the lowest figures of 1897–1905 and in 1933 to approximately the high figures of 1905–1924.

puerilities of the sort one hears around tickers in brokerage offices from disappointed speculators who have overstayed their market and are trying to "kid" themselves that the turn has not really come instead of seeing clearly what this situation is and selling out with the losses they have rather than staying on to run up greater losses.[8]

Let me quote from a paper by Carl Snyder[9] read in December, 1929. Speaking of brokers' loans and the pyramiding of credit he said: "My knowledge of financial history is not exhaustive, but so far as I have been able to discover there appears to have been nothing quite like it since the days of John Law and the Mississippi Bubble, and the South Sea Bubble in England. And apparently the process was almost identically the same. In the case of John Law he actually printed the money . . . with which the securities he issued were bought. . . . With a slight change in the counters, much the same thing appears to have characterized the last phase of our most spectacular stock boom. Our Wall Street financiers seemed to see no limits to which the fiction of 'new values' could be carried. What repercussion the collapse will have upon the industry and the employment of the country remains to be seen."

This is not economic or stock market forecasting, but merely a recognition that we do not know for certain what the future has in store, with the suggestion, based on analogy with a considerable number of past events of a somewhat similar nature, that the future may not be all rosy. It seems a very different note from Fisher's "Stock Market Crash and After."

In view of what I have said about the difficulty if not the impossibility of forecasting business activity or stock prices with any degree of assurance, you will realize that I could not blame Fisher for his wrong forecasts because they were wrong. True, I do not think a distinguished economist should make such wrong forecasts; but that is because I think he should know and should have known full well by 1929 that there is little reason to believe that sound forecasts can be made and should therefore restrain himself, as most good economists do, from spreading such forecasts in the press. So far as I can see, Fisher in 1929 missed foreseeing in any respect the greatest economic disturbance of this country, possibly the greatest of a century. He "explained away" the stock market crash; he did not see what it meant. It is difficult to see how anybody could have been much more wrong. Neither statistics nor economic theory saved him, indeed it is difficult to avoid the impression that his statistics and his economic theory did but serve to blind him the more completely to what was impending. If he were so wrong, then, what is the chance that he is right now, when the New Era economist has become a New Deal economist and when he who was loudly assuring us of the permanently high level of stock prices has become as loud an advocate of reflation? And what but discouragement can this kind of behavior be to social science or to those social scientists who believe that valid science, that science which is real science, whether in the social field or any other, must have some relation to what happens somewhere else than in the mind of him who elaborates it?

I will not attempt to sketch the economic reasons for any of our errors in forecasting, but I may perhaps allude to an error due to the limitations of limited statistical analyses. We have really numerous and comparable data available only over relatively short periods of time—in some lines only since the great war. Now the major economic swings may be of very long duration. Take, for example, the history of prices (Fig. 6). Different price indices will give results differing in detail, but by and large the facts are that prices were low between 1750 and 1770, were high during the revolutionary war (say around 1780), continued fairly high during the Napoleonic period with a peak in our war of 1812, were low from 1820 to 1860, high during the civil war, low from 1880 to 1910, and high during the recent war.

[8] I would commend the article of G. P. Watkins, *Jour. Amer. Statist. Assoc.*, 25: 169A, pp. 18–22, March, 1930, and especially his reference to the dangers of heavily discounting future earnings in the prices paid for stocks to any who have read Fisher's Chaps. V–VI, and to all who may become involved in some future market in which stocks are paying good dividends and yet are selling to yield only 2 per cent. to 3 per cent. in a time of reasonable prosperity and reasonably high money rates.

[9] *Jour. Amer. Statist. Assoc.*, 25: 169A, pp. 88–92, March, 1930.

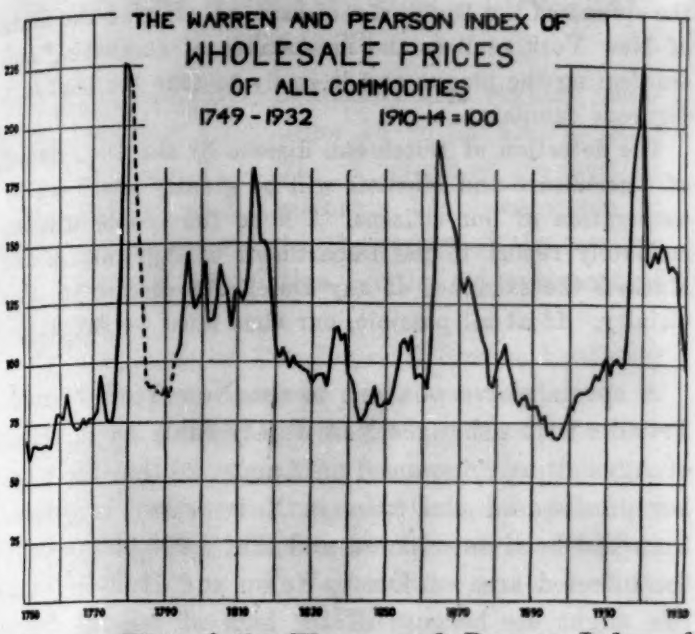

FIG. 6. Plot of the Warren and Pearson Index of Wholesale Prices, from figures in their book prices (John Wiley and Sons, 1933) on pp. 11–13.

On the index in the figure the 1926 price level was essentially a war level, a level which has been equalled for less than a decade during and after the civil war, for only about 5 years around 1812, and for only a few years around 1780. Possibly the 1926 level of prices has been equalled or surpassed only in some 25 years of the past 180—possibly one seventh of the time. What is the sense of talking about the 1926 level as normal? Can there be any such thing as a normal level? But the answers to these questions are not my main concern. I am trying to show that one important economic index *viz.*, that of wholesale prices, has very large long-term fluctuations. If you should try by any statistical means to forecast prices between 1913 and 1930 from the data for prices 1895 to 1913, you must inevitably fail.

Let me take another index, namely, Carl Snyder's comparison (Fig. 7) of bank credit versus the trend of trade.[10] Bank credit is a medium of exchange and trade is an exchange of goods; they may both be more than just that, it depends on one's definitions. You will note that the line for bank credit was constantly below that for the trend of trade from 1877 to 1907 and constantly above it from 1917 to 1932. I may again warn that other indices by other persons may show differences in detail, possibly considerable

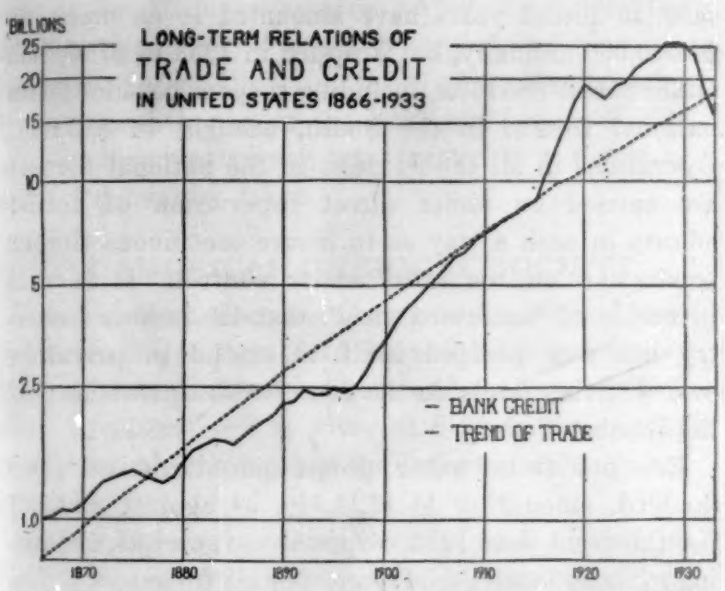

FIG. 7. Bank Credit and the Trend of Trade 1866–1933 (after Snyder).

differences; but the point is that we have had a major oscillation of the amount of credit about the trend of trade during the past 60 years, that in so far as Snyder's figures are sound (and they are the careful work of one who tries honestly to follow the statistical situation) we have had for about 15 years a great excess of bank credit over trade; that excess has now perhaps been liquidated. It is barely possible that it had to be liquidated. We are no longer adherents to the ancient motto, "Neither a lender nor a borrower be," we have departed far from the doctrine that "the borrower is servant to the lender," possibly the lender has become merely the dupe of the borrower; but under any system of folkways and mores in a society which uses credit, it may be that at times we have over-extension of credit. What then happens or what to do about it or what may now happen next I do not know. Perhaps others do not know. Whatever others may do, I do not pretend to know when evidence available to me shows that I have no business to claim to know. The reason we have so many failures in forecasting is that we presume to forecast the as yet unforecastable or attempt to control the as yet uncontrollable. So long as there are among us in high position those who exercise that presumption it may not be wholly amiss that a less competent, a less presumptuous person like myself, be permitted to address you on such a subject as I have to-night.

[10] *Economic Forum*, pp. 275–290, summer, 1933. Mr. Snyder has very kindly supplied the data from which to reproduce and bring up to date so much of his Chart II as I need in Fig. 7.

SCIENTIFIC EVENTS

RECEIPTS OF THE NATIONAL FORESTS

INCOME from the national forests for the fiscal year ending June 30, 1934, amounted to $3,314,691, an increase over 1933 of $688,642 or 25 per cent. Gains in timber and waterpower receipts were offset to some extent by decreases in revenues from grazing permits.

Timber sale receipts amounted to $1,499,216, resulting largely from renewed operations in sales contracted in previous years. National Forest timber

sales in recent years have amounted to as much as $4,000,000 annually, but dropped in 1933 to $756,747. Other forest products, including turpentine sales from national forests in the South, brought in $15,931. Operations in all timber sales in the national forests are carried on under direct supervision of forest officers in such a way as to insure continuous timber production on the areas under control. It is this principle of "sustained yield" that the lumber industry has now pledged itself to extend to privately owned timber lands, in the conservation provisions of the Lumber Code.

Receipts from water power permits more than doubled, amounting to $124,946, as against $60,191 for the fiscal year 1933. Special use receipts, including summer home permits and rentals for resort privileges, amounted to $297,830. No charges are made, however, for visiting or camping privileges in the national forests.

These gains in receipts were offset to some extent by the decrease of more than $100,000 in grazing fees. To meet emergency drought and other unfavorable conditions in the livestock range regions, the grazing fees were adjusted downward by Secretary Wallace, and grazing privileges for which the stockmen paid about $1,500,000 in the fiscal year 1933 brought considerably less in 1934. The figures for cattle and horses were $764,686; for sheep and goats, $579,624.

The only region to suffer a net loss in national forest receipts was the southwestern region, including New Mexico and Arizona, where large areas of national forest land are devoted to grazing.

Twenty-five per cent. of the receipts of national forests are turned over to the states to be pro-rated to the counties in which the forests are located, for road and school purposes. An additional 10 per cent. is earmarked for expenditure on national forest road construction in the counties of origin.

THE ELM TREE DISEASE IN NEW YORK AND NEW JERSEY

THE $155,000 appropriation for eradication of the Dutch elm disease, which was passed at the extra session of the New York Legislature, has received approval of Governor Herbert H. Lehman.

He has issued a memorandum calling upon citizens to cooperate in combating the disease. Out of the $155,000 appropriated, $142,500 is for the Department of Agriculture and Markets for eradication purposes and $12,500 for the State College of Agriculture, Cornell University, for investigating the disease. The Governor wrote:

> The Dutch elm disease is growing in virulence in this state. I have had communications from the governors of neighboring states in which they express concern about the spread of the Dutch elm disease. I am glad the State of New York realizes the importance of combating and eradicating the plague and is ready to take the lead in a vigorous campaign.
>
> The detection of Dutch elm disease by the Department of Agriculture and Markets will be greatly expedited by cooperation of our citizens. I hope the people will immediately report to the Department of Agriculture and Markets the existence of any Dutch elm disease in their vicinity. If at all possible, our elms must be saved.

A special correspondent to the New York *Herald-Tribune* writes that the New Jersey State Department of Agriculture announced on August 24 that the number of diseased elm trees in New Jersey is greater than had been anticipated and that 1,000,000 trees in the infected area of Essex, Union and Hudson counties might die because of the lack of federal funds for their care.

The Legislature has appropriated $30,000 to destroy infected trees and already 731 have been cut down. William B. Duryee, Secretary of Agriculture, stated the sum of at least $250,000 would be needed for the present fiscal year and the next to remove trees that present estimates show are likely to be infected during the next eighteen or twenty months.

It is proposed to use the balance of federal and state funds available to establish a barrier zone five to ten miles wide around the infected area, removing elms in that sector to prevent the outward spread of the disease and abandoning elms within the infected area to their fate.

Lee A. Strong, chief of the Bureau of Entomology and Plant Quarantine, has recently issued a statement in which he said:

> A diseased tree can not be treated; it must be removed and burned. It is believed that a small beetle which infests the trees carries the disease to uninfected trees. If diseased and beetle-infested trees are not removed and immediately burned, the beetles leave the infected trees and move to uninfected trees. Thus the disease is rapidly and widely spread. The indications are that unless a vigorous, consistent program is carried out to remove and burn every infected tree, the elms of America may follow the American chestnut to almost complete destruction by disease. All the United States Department of Agriculture can do with the limited funds at its disposal is to conduct scouting operations to find the diseased trees and coordinate the eradication activities, although some money is being spent to take out trees which are obviously most dangerous to areas not yet infected and which otherwise could not be removed in time. If individuals, cities, counties and states will at once undertake and aggressively carry out the right kind of a program of eradication, there is a fair chance of eradicating the disease. Failure to do this probably means dedicating the elms of America to disease and death.

MEETINGS OF THE AMERICAN PHYSICAL SOCIETY

THE American Physical Society held regular meetings at Berkeley from June 18 to 23 and at Ann Arbor from June 28 to 30. A report of the meeting at the University of California has been given in SCIENCE in connection with the report of the meeting of the American Association for the Advancement of Science.

In the last issue of *The Physical Review* Professor W. L. Severinghaus, secretary of the society, gives an account of the proceedings of the meeting at the University of Michigan according to which the presiding officers were Professor Arthur H. Compton, president of the society, and Professors Robert S. Mulliken and N. H. Williams. The attendance at the sessions was about two hundred and fifty.

The meetings on the first day were held in Dearborn, Michigan. The morning was occupied by a visit through the Greenfield Village Museums. After luncheon at the Dearborn Inn there was a lecture by C. E. Johansson of the Ford Motor Company on "Precision Gauges." After the lecture the members of the society were taken to the Ford plant at River Rouge for a trip through the plant.

The scientific sessions on Friday and Saturday were held in Hutchins Hall at the University of Michigan. These lecture rooms were extraordinary both in the beauty of their appointments and in the fact that they were air-conditioned. The Friday morning program consisted of three parallel sessions of contributed papers. On Friday afternoon there was a lecture by Professor George Gamow, of the Polytechnical Institute, Leningrad, Russia, on "The General Nuclear Problem." On Saturday morning there was a symposium on "Nuclear Moment." The invited papers were as follows: "Theory of the Effect of a Nuclear Moment on the State of the Atom," by G. Breit, of New York University; "Measurement of Nuclear Spin and Statistics by Means of Band Spectra," by Robert S. Mulliken, of the University of Chicago; "Survey of Experimental Hyperfine Structure Material. Values of Nuclear Magnetic Moments and a Discussion of Their Origin," by Robert F. Bacher, of the University of Michigan; "Measurement of Nuclear Spin and Moments by Method of Molecular Beams," by I. I. Rabi, of Columbia University; "Measurement of Nuclear Moments and Spin through the Polarization of Resonance Radiation," by Alexander Ellett, of the State University of Iowa. The regular scientific program consisted of forty-five papers.

On Friday evening one hundred and forty-three members attended the society dinner in the dining room at the Michigan League. After the dinner the Michigan Repertory Players presented the play "A Hundred Years Old" in the Lydia Mendelssohn Theater which is also in the Michigan League Building. Saturday afternoon was devoted to a picnic at one of the near-by lakes.

THE AMERICAN CHEMICAL SOCIETY

THE American Chemical Society will meet at Cleveland from September 10 to 14, under the presidency of Dr. Charles L. Reese. Dr. Reese's address on "Scientific Idealism" will be given at 8:30 in the evening of the first day following the informal subscription dinner.

At the opening general meeting at 2 o'clock on Monday four general papers will be presented. These are:

J. R. Katz, Scheikundig Laboratorium, University of Amsterdam. "X-Ray Spectrography of Swelling."

Robert E. Swain, Stanford University, California. "Chemistry during the Depression."

N. K. Chaney, V. C. Hamister and S. W. Glass, National Carbon Company, Inc. "Constants of Carbon at Arc Temperatures."

J. C. Hostetter, Corning Glass Works. "The Technic of Making Large Telescope Mirrors."

The divisions in which the society will meet, with the chairmen and the number of papers to be presented, are:

Agricultural and Food Chemistry, 30 papers; Dr. Donald K. Tressler, chief chemist, The Birdseye Laboratories, Gloucester, Mass.

Biological Chemistry, 43 papers; Dr. Robert C. Lewis, professor of biochemistry at the University of Colorado School of Medicine.

Cellulose Chemistry, 6 papers; Dr. C. E. Curran, chemist, of the Section of Pulp and Paper of the Forest Products Laboratory, Madison, Wis.

Chemical Education, 26 papers; Dr. Ross Allen Baker, professor of chemistry, in charge of the department, Commerce Center of the College of the City of New York.

Colloid Chemistry, 19 papers; Dr. Wesley G. France, professor of colloid and electro chemistry, the Ohio State University.

Fertilizer Chemistry, 23 papers; Egbert W. Magruder, control and chief chemist, F. S. Royster Guano Company, Norfolk, Va.

Gas and Fuel Chemistry, 32 papers; Harold J. Rose, senior fellow, Mellon Institute, Pittsburgh.

History of Chemistry, 7 papers; Dr. Frank Burnett Dains, professor of chemistry, University of Kansas.

Industrial and Engineering Chemistry, 16 papers; Walter G. Whitman, chemical engineer, associate director of research, Standard Oil Company of Indiana, Whiting, Ind.

Medicinal Chemistry, 31 papers; Dr. Paul Nicholas Leech, director of the Chemical Laboratory of the American Medical Association, Winnetka, Ill., and secretary of the Council on Pharmacy and Chemistry.

Organic Chemistry, 43 papers; Dr. Claude S. Hudson, professor of chemistry, National Institute of Health, U. S. Public Health Service, Washington, D. C.

Paint and Varnish Chemistry, 16 papers; Robert J. Moore, development manager, Varnish Resin Department, the Bakelite Corporation, Bloomfield, N. J.

Petroleum Chemistry, 11 papers; Dr. F. W. Sullivan, Jr., director of research, Standard Oil Company of Indiana, Whiting, Ind.

Physical and Inorganic Chemistry, 92 papers; Dr. Donald H. Andrews, professor of chemistry, the Johns Hopkins University.

Rubber Chemistry, 44 papers; Professor Ira A. Williams, consulting geologist, Portland, Ore.

Sugar Chemistry, 7 papers; Otto A. Sjostrom, research chemist, Corn Products Refining Company, Argo, Ill.

Water, Sewage and Sanitation Chemistry, 20 papers; Edward S. Hopkins, sanitary chemist, Bureau of Water Supply, Baltimore, Md.

The usual entertainments have been arranged and visits to commercial firms in and near Cleveland will include The National Carbon Company, The Ferro Enamel Company, The Glidden Company, Easterly Sewage Disposal Plant, Baldwin Filtration Plant, Industrial Rayon Corporation, Otis Steel Company, American Gas Association Laboratory, General Electric Company, Nela Park, and Pitney Glass Works, The Westinghouse Electric and Manufacturing Company, Willard Storage Battery Company, the Westerly Sewage Disposal Plant, the Firestone Tire and Rubber Company, the General Tire and Rubber Company, the B. F. Goodrich Rubber Company, the Goodyear Tire and Rubber Company, and the Brewing Corporation of America.

RECENT DEATHS

FRANK EVANS SEAGRAVE, astronomer and mathematician, owner and director of an observatory at North Scituate, R. I., died on August 15, at the age of seventy-four years. Mr. Seagrave took part in solar eclipse expeditions in 1878, 1887 and 1900. He was for forty years night editor of the Boston *Globe.*

DR. WILLIAM A. P. GRAHAM, associate professor of geology at the Ohio State University, died suddenly on August 11, at the age of thirty-five years. He was, at the time, engaged in geological work in the Sweet Grass Hills in northern Montana. Dr. Graham had held teaching positions at the University of Iowa and Texas Technological College and had been at the Ohio State University since 1928.

DR. EDWARD R. BERRY, for many years a member of the research staff of the General Electric Company, died on August 17, at the age of fifty-five years.

DR. ARTHUR LATHAM BAKER, formerly head of the department of mathematics at Manual Training High School, Brooklyn, died on August 13, at the age of eighty-one years.

DR. GEORGES DREYER, professor of pathology at the University of Oxford since 1907, died suddenly on August 17. He was sixty-one years old.

HERMANN GLAUERT, principal scientific officer at the Royal Aircraft Establishment at Farnborough, died on August 6, as the result of an accident. He was forty-one years old. Mr. Glauert was a fellow of the Royal Society and a fellow of Trinity College, Cambridge; he had been engaged on research in aerodynamics at the Royal Aircraft Establishment since 1916.

DR. EDWIN WARD, director of the Royal Scottish Museum, Edinburgh, died on August 10, at the age of fifty-four years.

SCIENTIFIC NOTES AND NEWS

THE honorary doctorate of natural science has been conferred by the University of Frankfort-on-Main on Professor Henry Fairfield Osborn, honorary life president of the American Museum of Natural History.

DR. EUGENE ALLEN GILMORE, dean of the College of Law of the Iowa State University, has been elected to the presidency. He succeeds Dr. Walter Albert Jessup, who recently resigned to become president of the Carnegie Foundation for the Advancement of Teaching.

DR. CHARLES F. MARVIN, chief of the Weather Bureau from 1913 to 1934, retired from the government service on August 25 on the fiftieth anniversary of his enrolment. He had continued in service to complete a half century of government work. Dr. Willis R. Gregg has succeeded Dr. Marvin as chief of the bureau.

JULIAN S. HUXLEY, from 1925 to 1927 professor of zoology at Kings College, University of London, and now honorary lecturer, has been nominated to the secretaryship of the Royal Zoological Society for election at the annual meeting next April. He will succeed Sir Peter Chalmers Mitchell, since 1903 secretary of the society, who reaches the age of seventy years in November.

ACCORDING to *Nature,* Professor C. E. Weatherburn, who holds the chair of mathematics in the University of Western Australia, has been awarded the

Hector Medal and Prize by the Royal Society of New Zealand, for his contributions to differential geometry.

THE von Wieser Medal of the Museum Ferdinandeum has been awarded to Dr. Albrecht Penck, professor of geography in the University of Berlin, for investigations in the Tyrol.

DR. BRUNO GEBHARD, director of the German Museum of Hygiene, Munich, was the guest of honor on August 24 at a luncheon attended by public health officials at the Metropolitan Life Insurance Building, New York City. Dr. Gebhard is on his way to attend a meeting of the American Public Health Association at Pasadena, California, in September.

W. H. FULWEILER, chemical engineer of the United Gas Improvement Company, Philadelphia, has been elected a vice-president of the International Association for Testing Materials.

THE British Institution of Electrical Engineers has nominated officers for vacancies occurring on September 30 as follows: *President,* Professor W. M. Thornton; *Vice-presidents,* W. E. Highfield and Lieutenant-Colonel A. G. Lee; *Hon. Treasurer,* F. W. Crawter.

Nature states that at the invitation of the Council of the Pharmaceutical Society of Northern Ireland, the British Pharmaceutical Conference will be held in 1935 in Belfast. The following officers have been elected: *Chairman,* Dr. F. W. Crossley-Holland; *Treasurer,* Mr. T. E. Lescher; *General Secretaries,* Mr. C. E. Corfield and Mr. G. R. Boyes.

PROFESSOR H. SCHOTTMÜLLER, of Hamburg, has been elected president of the German Society of Internal Medicine for 1935.

DR. RICHARD E. MCARDLE, chief of the section of silviculture of the Pacific Northwest Forest Experiment Station, Portland, Ore., has been elected dean of the School of Forestry of the University of Idaho, to take the place of Dean Francis Garner Miller, who died last March after a period of service of seventeen years.

DR. CARL C. LINDGREN, research assistant in microbiology at the Mellon Institute, Pittsburgh, has been appointed chairman of the newly established department of bacteriology at the University of California at Los Angeles.

DR. HELEN J. HUBBELL has been appointed assistant professor of nutrition at Yale University.

C. H. SHOWALTER, formerly with the Lawrence Engineering Research Corporation in New York City, has been appointed instructor in aeronautical engineering at the University of Idaho.

DR. MATILDA MOLDENHAUER BROOKS has been appointed lecturer in zoology during the fall semester to give courses in physical-chemical biology at the University of California in the absence of Professor S. C. Brooks.

DR. C. B. JOLLIFFE, formerly chief engineer for the discontinued Federal Radio Commission, has been reappointed as chief engineer with the Federal Communications Commission. W. G. H. Finch, formerly chief engineer of the American Radio News Corporation and at one time consulting engineer in New York City, has been made an assistant chief engineer.

Industrial and Engineering Chemistry writes that "Domenico Marotta has recently been appointed chief of the chemical laboratory of the Public Health Service of Italy. Professor Marotta is internationally known for his important and numerous scientific publications. He is a member of the council of the International Union of Chemistry and of many commissions, and is general secretary of the Associazione Italiana di Chimica, which owes its great progress to him."

ACCORDING to *Current Science,* Bangalore, Rao Bahadur B. Viswanath, now agricultural chemist to the government of Madras, has been appointed imperial agricultural chemist. He will work at the Pusa Research Institute. Dr. Hem Singh Pruthi, of the Zoological Survey of India, has been appointed agricultural entomologist. The Agricultural Research Station, now at Pusa, the buildings of which were seriously injured in the last earthquake, will be transferred to a suitable site in the vicinity of Delhi.

THE Rockefeller Foundation has appropriated $5,000 in support of a study of the chemical aspects of vitamins and hormones under the direction of Dr. Herbert M. Evans, of the University of California.

A GRANT of $1,000 has been made by the Simon Baruch Foundation for Medical Research, through the generosity of Dr. Herman Baruch, its founder, to the Pathological Laboratories of St. John's Hospital, Brooklyn, to carry forward an investigation by Dr. Theodore J. Curphey on the effect of foetal endocrine tissue extracts on cell growth.

THE following grants have been made by the Committee on Scientific Research of the American Medical Association: Ernest C. Faust, New Orleans, for the completion of a study on *Strongyloides stercoralis;* W. J. Nungester, Northwestern University Medical School, Effect of Mucin on Infection; Edward J. Van Liere, University of West Virginia, Effect of Anoxemia on Smooth Muscle; Wm. de B. MacNider, University of North Carolina, Establishment of Artificial Circulation in the Kidney; Timothy Leary, Boston,

two grants, Cholesterol Atherosclerosis; Rachel E. Hoffstadt, University of Washington, Protein and Carbohydrate Fractions of *Staphylococcus aureus;* W. R. Tweedy, Loyola University School of Medicine, Parathyroid Hormone; Jane Sands Robb, Syracuse University, Individual Cardiac Muscles; Alexander S. Wiener, Brooklyn, Agglutinogens and Agglutinins of Human Blood and their Heredity; John R. Murlin, University of Rochester Medical School, Chemical and Physiological Properties of the Male Hormone; W. T. Dawson, University of Texas School of Medicine, Cinchona Alkaloids; Arthur J. Geiger and Louis S. Goodman, Yale University, the Antianemic Principle; H. A. Kemp, W. H. Moursund and H. E. Wright, Baylor University College of Medicine, Relapsing Fever in Texas; E. Brand and G. F. Cahill, New York State Psychiatric Institute and Hospital, Cystinuria.

DR. EDWARD C. ROSENOW, of the Mayo Clinic, at Rochester, Minn., who was invited to go to Cuba by President Carlos Mendieta to assist the medical authorities in combating the wave of infantile paralysis which has taken twenty-five lives in the last two months, arrived at Havana on August 19.

JASON R. SWALLEN, assistant agrostologist of the Bureau of Plant Industry, U. S. Department of Agriculture, has returned to Washington after nine months spent in northern Brazil studying and collecting grasses. He visited the states of Rio Grande do Norte, Ceará, Piauy, Maranhão and Pará along the Amazon as far as the Tapajos River.

DR. KATSUMA DAN, of the department of physiology in the University of Pennsylvania, is leaving for an extended visit to Japan.

THE next biennial Organic Chemistry Symposium of the American Chemical Society will be held at Rochester, N. Y., in December, 1935. The exact dates have not yet been determined, but they will probably be from December 30, 1935, to January 1, 1936. The first Organic Chemistry Symposium was held in Rochester, and the forthcoming sixth symposium will mark the tenth anniversary.

BY the will of the late Mrs. Perla A. Brickman the following bequests are made: The Hospital for Joint Diseases, New York City, $15,000; The New York Academy of Medicine, $10,000; The American College of Surgeons, Chicago, $1,000; The Gorgas Memorial Institute of Tropical and Preventive Medicine, Inc., Washington, D. C., $1,000, and The New York Physicians Mutual Aid Association, $1,000.

THE University of California has received the sum of $1,820 from Merck and Company, Inc., Rahway, N. J., to establish "The Merck Fellowship in Pharmacology" for the academic year 1934–35.

A COPY of "Prodomus Faunae Rossicae—Preliminary Account of the Russian Fauna"—by Joanne Dwigubski, published in Göttingen, Germany, in 1804, has come to light in the library of the Academy of Natural Sciences of Philadelphia. This thin volume, printed in Latin on hand-made paper, bound in the original blue papers, and containing one copperplate engraving of a certain species of mole, has been in the library for many years, but remained in obscurity because no one ever had asked for it. The book is uncut from cover to cover and is in excellent condition.

THE London *Times* reports that the Australian Federal Government has accepted the offer of Mr. Donald Thompson, of the staff of the University of Melbourne, to live among the Arnhem Land aboriginals, in order to study their habits and customs. Mr. Thompson has already lived for two years among the North Queensland aboriginals studying sociological organizations, folk lore and hero cults. He won this year's anthropological scholarship at the University of Melbourne for his work on aboriginal sociology. Mr. Thompson will be appointed Federal Control officer, but will be free to carry out work in his own way, submitting periodical reports.

THE African Prehistoric Research Expedition, under the leadership of T. P. O'Brien, left London for Uganda on August 15. The expedition, undertaken with the approval of the Uganda government, will devote a season of eighteen months or two years to archeological work in the Protectorate. The London *Times* points out that East Africa is one of the richest fields for the study of Stone Age archeology. Uganda offers a wealth of sites which cover the greater part of Stone Age times. Deposits containing Late Pliocene and Early Pleistocene fauna exist in several parts of the country, and there is said to be a strong possibility that artifacts and, perhaps, human skeletal remains of very early times may also be brought to light. During its first season, however, the main object of the expedition will be the study of the Middle and Upper Paleolithic cultures.

Nature reports that it is announced that an expedition, of which Dr. Quaritch Wales is field director, will leave England for India in October next for the purpose of archeological exploration in Lower Burma and Siam. His Highness the Maharajah Gaekwar, of Baroda, has contributed £500 towards the expenses of the expedition, which will be known as the Gaekwar of Baroda Greater Indian Research Expedition. The work of organization has been in the hands of a small committee of the Royal Asiatic Society, the India Society and the School of Oriental Studies, under the chairmanship of Sir Francis Younghusband. The area which the expedition proposes to explore is one of the few districts of Further India

and beyond which is still unexplored, and it may be anticipated that the expedition, under the leadership of Dr. Wales, who has already done valuable work in Siam, will yield material which will throw light on artistic and religious development in Further India and Siam and the cultural relations of these countries to the art, culture and religions of ancient India.

BY a recent act of the Congress, all persons over sixteen years of age who wish to hunt migratory waterfowl will hereafter be required to carry a federal hunting stamp. These stamps will be sold at $1 each at all post offices in towns of 2,500 population or more and also at post offices at all county seats. In addition, certain other post offices conveniently located will be authorized to issue the stamps in order to make it easy for the sportsman to comply with this new federal law. Persons who collect migratory birds for scientific purposes must also have the stamp, in addition to the Federal scientific collecting permit prescribed. The stamps will be ready for issue about July 1, and are good for one year. The fund derived from the sale of these stamps has been set aside by the Congress to be used in purchasing or leasing marsh and water areas to be acquired as inviolate refuges for ducks and geese and other waterfowl.

DISCUSSION

THE DISCOVERY OF AN ANCIENT MINNESOTA MAKER OF YUMA AND FOLSOM FLINTS

SATURDAY, July 28, 1934, I had the satisfaction of confirming an earlier private report of the finding in Minnesota of a human skeleton associated with ancient flint artifacts of the now famous Yuma and Folsom types. A fuller report of the discovery, the fragmentary skeleton and the artifacts will be made later in association with Mr. William H. Jensen, of Brown's Valley, Minnesota, to whose quick intelligence the rescue and conservation of the find is due. Since Mr. Jensen was nine years old he has been an ardent collector of Indian artifacts along both the eastern and western shorelands of Traverse and Big Stone lakes, boundary waters for some seventy miles between Minnesota and South Dakota.

In the fourteen-foot pluvial gravel of a plateau, once an island in Glacial River Warren (the earliest and southern outlet of Glacial Lake Agassiz), the skeleton and artifacts in question were dug out, but unnoticed, by a drayman who on October 9, 1933, was hauling gravel for repairing a driveway at the Jensen grain elevator. At the driveway Mr. Jensen noticed a flint implement in the gravel as it was being unloaded. He also then and there picked up small fragments of bone which proved to be human. On going immediately to the gravel pit he picked up the human skull frontal, other small fragments of the skull, two fragments of jaws and also fragments of long bones. All the bones recovered lay close to the bottom of the vertical face of the stratified gravel—which face was then exposed about seven feet high.

In the face of the gravel Mr. Jensen readily identified the exact spot from which the bones had fallen. Still within the skeletal pit (in all probability a grave) he saw at the depth of four and one half feet from the surface the exposed tip of a second flint implement. This he dug out. In the loose gravel fallen from the face of the wall he found a third flint implement. In the partially filled dray, being reloaded with gravel for the elevator driveway, he found a fourth flint artifact. Nearby in a junk heap he picked out an old five-gallon gasoline can; this he filled with gravel lying immediately beneath the skeletal pit. Later at home he rescued from the can of gravel a fifth flint and two fragments of a dresser of sandstone.

Thus last October there had been found by Mr. Jensen personally, or found in his presence (and always also in the presence of other witnesses), a human skeleton with five flint artifacts of Yuma chipping, three of which are of Folsom outline. He first wrote to me in January, 1934. It was not until July 21, 1934, that I could go to the site of the find, after discovery on June 24, from a photograph, of the unmistakable Yuma and Folsom characteristics of the flints. With a field class of six students in archeology I redug the gravel which had fallen in the vicinity of the skeletal pit of last October. We dug and sifted July 28, 30 and 31. We found seventeen additional bone fragments, some of which contacted with cranial fragments earlier secured by Mr. Jensen. We found also a tooth from one of the jaw fragments, and, most surprisingly, found a sixth flint artifact. It is practically a duplicate of the most perfect one in the earlier find and is Folsom in all particulars, except that both faces are of characteristic Yuma chipping instead of being excavated in the Folsom manner.

Western Minnesota thus is shown to be of great significance for early man in the Western Hemisphere. Not only has she produced the "Minnesota Man" of late Glacial Age, but she now reveals the Brown's Valley Man, who is the first recorded maker of either of those acknowledged ancient American flints known as Yuma and Folsom. The two flints are culturally closely related.

ALBERT ERNEST JENKS
UNIVERSITY OF MINNESOTA

A POSSIBLE DIETARY PREDISPOSITION TO STAMMERING

IN working with stammering patients over a considerable period, it has been impressed upon me that while there are a number of specific causes for the habit, each of which must be treated on its own basis, there are probably certain predisposing causes which are also predisposing to other objectionable habits. A habit, as a habit, may be broken; but obviously this is not a final solution of the problem if either specific or predisposing cause is still active.

In the cases of many stammerers whose childhood histories could be reconstructed with reasonable fullness of detail, it has appeared that improper diet in infancy and childhood may have been an important predisposing factor. Further survey of stammering cases, made with the assistance of Dr. Vernon Scheidt, has strengthened my suspicion that an insufficiency of meat in the diet is a predisposing factor in a great many cases. Being unable to carry this survey farther at the present time, it seems appropriate to present the suggestion to all who have opportunities to study stammering cases and who may be able to experiment by placing on an adequate meat diet stammering children who have been on an almost exclusive vegetarian diet.

From the age of two years, there is no reason why children should not have meat at least twice a day. In many cases where the diet has previously been badly managed, the problem may be to induce the child to eat a sufficient quantity. Variety of meats and of preparation, with good psychological technique, offer the solution to this problem. Overcooked meats should probably be avoided.

In some cases, children who have been reared on a diet which includes meat (beginning with liver) from the age of three months refuse to eat meat except sparingly, when they have attained several years of age. In some such cases, the incidence of stammering has been noted. Further observations on such cases and on children who have continued without interruption an adequate meat diet are needed. In the cases of adolescents and those of later ages, adequate information concerning the diet of infancy and early childhood is obtained with difficulty, on account of the well-known unreliability of the reports of both individuals and their mothers concerning matters of early life. In many cases, however, sufficiently accurate accounts of the dietary régime can be secured, and the collection of these seems to be of importance.

For stammering adults, it is conjectural whether a full meat diet would be helpful, along with proper psychological treatment of the habit. The situation of the adult stammerer is of course quite different from that of the stammering child or adolescent. That which may be a predisposing cause in infancy may have other bearings in adult life. Since a surprisingly large number of adult stammerers are relative vegetarians, however, it would seem possible that meat diet would be advantageous to many of these cases.

KNIGHT DUNLAP
THE JOHNS HOPKINS UNIVERSITY

OCCURRENCE OF A PHYTOSTEROL IN AFRICAN OIL PALM (ELAEIS GUINEENSIS)[1]

IN the course of an investigation dealing with the separation of α-carotene from a commercial carotene product representing chiefly the unsaponifiable fraction of palm oil, there were obtained several grams of a substance which gave a strong phytosterol reaction.

The alcoholic mother liquor remaining after the separation of most of the carotene was mixed with petroleum ether and sufficient water added to bring the alcohol content to 85 per cent., whereupon a separation of crystalline material occurred. After being filtered and recrystallized, first from 95 per cent. alcohol and finally from absolute alcohol, white plate-like crystals melting at 136.2 to 136.5° and giving a positive Liebermann-Burchard reaction were obtained. Acetylation with acetic anhydride yielded an acetate melting at 130.5 to 131.5° C. and having a specific rotation in $CHCl_3$ $(\alpha)^{20}_D$ –36.5°. The regenerated parent substance melted at 136.5 to 137° C. and had a specific rotation in $CHCl_3$ $(\alpha)^{20}_D$ –41.66°.

From these data it is concluded that palm oil phytosterol probably consists chiefly of sitosterol.

K. S. MARKLEY
M. B. MATLACK
U. S. DEPARTMENT OF AGRICULTURE

BACTERIA-FREE CULTURE OF PARAMECIUM

THERE are two reports in the literature on the successful culture of *Paramecium* in bacteria-free media. Glaser[1] demonstrated such cultures of *P. caudatum* and *P. multinucleata,* and later Glaser and Coria[2] outlined the culture methods employed for *P. caudatum*. Recently Hetherington[3] has questioned the bacteria-free nature of their cultures because he was unable to repeat their method with success. The following results may be of interest in this connection. In November, 1933, *P. bursaria* was washed according to the method of Parpart[4] and has since been successfully cultured in a synthetic peptone medium.

[1] Food Research Division Contribution No. 223.
[1] *Jour. Parasit.*, 19: 13, 1932.
[2] *Jour. Parasit.*, 20: 33–37, 1933.
[3] SCIENCE, 79: 413–414, 1934.
[4] *Biol. Bull.*, 55: 113–120, 1928.

Repeated sterility tests indicate the complete absence of bacteria and show that this species is capable of growth under such conditions. The zoochlorella which the ciliate ordinarily harbors has been cultured independently on agar slants. Further studies on the symbiotic relationship of these forms are in progress.

JOHN B. LOEFER

NEW YORK UNIVERSITY

SPECIAL CORRESPONDENCE

THE SCARRITT EXPEDITIONS OF THE AMERICAN MUSEUM OF NATURAL HISTORY, 1930–34

THE Scarritt Expeditions have now completed their fourth year of continuous work, and a preliminary account of progress made is here presented. Sponsored by Mr. H. S. Scarritt, of New York, the purpose of the expeditions has been to collect and to study early Tertiary fossil mammals, especially those of South America. This work continues the program of early Tertiary exploration initiated at the American Museum by Professor H. F. Osborn more than forty years ago, continuously and vigorously pursued in many parts of the world by Wortman, Granger, Matthew, Andrews, and many others. Such exploration had not previously been done by this institution in South America, and the first aim of the Scarritt Expeditions was to fill this gap in our exhibition and study series, and to cast needed light on the most neglected part of the world problem of early mammalian evolution.

The American personnel has consisted of G. G. Simpson, leader, and C. S. Williams, assistant, throughout the period now completed. In the field in Patagonia a number of local assistants have been employed at various times. Of these Justino Hernández is worthy of special mention.

The first Patagonian Expedition, 1930–31, left New York on August 8, 1930, and sailed direct to Buenos Aires by the east coast of South America. Negotiations for permits to explore were delayed by the Argentine revolution of September 6, 1930, but the expedition arrived at its principal base, Comodoro Rivadavia in southern Chubut (central Patagonia) on September 28. Until December 2 we worked in the general region south of Lake Colhué Huapí, then after a reconnaissance west of the Sierra San Bernardo spent eight days north of the lake. On December 18 a base camp was established in Cañadón Vaca, north of the Río Chico, which forms the drainage from Lakes Musters and Colhué-Huapí into the Chubut River. Here a remarkably rich deposit of the oldest of Ameghino's faunas, the so-called *Notostylops* fauna, was discovered and worked with great success for two months. From February 18 to March 22 work was continued in Cañadón Hondo, opposite Cañadón Vaca south of the Rio Chico. Thereafter work was principally stratigraphic and geological reconnaissance, with no attempt at intensive collecting. Our route took us to Cabeza Blanca, made famous by the Amherst Expedition under Loomis, then to the northern coast of the great Gulf of San Jorge at Bustamante, and southward along the whole coast-line to Puerto Deseado. On April 23 we returned to Comodoro on our way north, and after shipping most of the collections by sea to Buenos Aires drove overland to that city, which was reached on May 12.

The collection was cleared for export and Williams returned with it to New York, sailing on June 6, and there began the unpacking and preparation which occupied him for most of the following two years. Simpson remained in the Argentine until October 10, 1931, studying the great Ameghino Collection in the Museo Argentino de Ciencias Naturales[1] in Buenos Aires and the Roth Collection in the Museo de La Plata.

The end of 1931, all of 1932 and the first half of 1933 were occupied by the preparation, illustration and study of the collections of the first expedition.

The Scarritt Expedition of 1933–34 was also directed to Patagonia, with the purpose of completing the collections of the first expedition and particularly of investigating rumors of a rich fossil field in central Chubut, north of the area of most intensive previous work. Simpson and Williams sailed from New York on September 9, 1933, through the Panama Canal, and down the west coast of South America to Valparaiso, thence by rail to Santiago de Chile and by air to Buenos Aires. Preliminary negotiations occupied two weeks, and the party left Buenos Aires by motor truck on October 17. The route followed was westward through Buenos Aires Province into the Territory of La Pampa, thence south across the Río Colorado at Balsa la Japonesa, a brief visit to the Cretaceous strata of eastern Neuquén, a week working on the Cretaceous-Tertiary contact opposite (south of) Roca, and then cross-country to Trelew on the Río Chubut. Here Justino Hernández joined the party and junction was effected with Sr. Alejandro Bordas, working on behalf of the Argentine Museum of Buenos Aires, with whom we collaborated here and also later in the Colhué-Huapí region. After seventeen days near Trelew and Gaiman, the Scarritt Expedition went up the Chubut Valley to Paso de los Indios, a traverse

[1] Its present name. At that time still called the Museo Nacional de Historia Natural.

in which reports by Roth and others of mammal beds proved to be incorrect, and then southward into unmapped central Chubut. After much searching, the richest strike of the expedition was made here on December 5, 1933, in a large amphitheater known locally as the Rinconada de los Lopez. Work on this discovery continued until February 4, 1934, and after a period spent in carting and packing fossils and repairing damage done to the car by the extremely difficult traveling conditions, a short time was spent rechecking and adding to observations made by the first expedition south of Lake Colhué-Huapí. The field season was closed and the party moved to Comodoro Rivadavia on February 27. The collection was shipped by government tanker, and we proceeded to Buenos Aires by land, picking up the Trelew collection at that town and following the same route as in 1931.

After lengthy negotiations and with some difficulties which need not be detailed at this time, the second collection was also cleared and is now in New York.

In the course of the two Patagonian expeditions, the party traveled over 12,000 miles in the field and made a reconnaissance, from the view-point of its special aims, of an area of over 30,000 square miles. Detailed studies were made at twenty-five different localities. Fifty-four detailed geologic sections were measured, and many others sketched or estimated. Almost every known exposure of the early Tertiary in Patagonia was examined, including several hitherto unknown, and detailed observations on their stratigraphy and structural geology made. These stratigraphic results will considerably alter the present conception of the Cretaceous-Tertiary transition in South America. Aside from a series of rock samples from all the principal exposures and horizons and a few small miscellaneous collections, the Scarritt Collection consists of fossil vertebrates. Many fish, frogs, birds, crocodiles, turtles and snakes are included, giving a remarkably complete picture of the early Tertiary life of the region. Some of the members of these hitherto neglected or undiscovered groups prove to be of extraordinary interest and value. Mammals, the principal aim of the expeditions, are still better represented, with fine typical collections from all the known pre-Patagonian (i.e., Paleocene through Oligocene) mammal-bearing formations, including the oldest, the Río Chico Formation, first recognized and defined by us, as well as the Casamayor, Musters, Deseado and Colhué-Huapí, from which, respectively, came the *Notostylus, Astraponotus, Pyrotherium* and *Colpodon* faunas of Ameghino. A number of new forms are included, but it is considered still more important that many relatively complete specimens were discovered of animals previously named on the basis of scraps and single teeth and hitherto more confusing than helpful.

Work on this great collection of data and specimens will not be completed for several years, but is being pushed as rapidly as possible. Twenty-one preliminary papers have been published, and several others are in preparation. A book, "Attending Marvels: a Patagonian Journal," gives a popular narrative of the first expedition. An extensive memoir on the stratigraphy and faunas of the Cretaceous-Tertiary transition and the Río Chico, Casamayor and Musters Formations is about one third completed. A shorter résumé and revision of the Roth Collection is completed and will be published by the Museo de La Plata. A detailed descriptive catalogue of the *Notostylops* and *Astraponotus* faunas in the Ameghino Collection is nearly completed and will be published by the Museo Argentino de Ciencias Naturales.

Aside from the completion of this research, future plans for the Scarritt Expedition include the extension of its collecting activities into other fields, and negotiations toward this end have already been started, but an announcement of definite plans would now be premature.

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SCIENTIFIC APPARATUS AND LABORATORY METHODS

THE OBSERVATION OF MITOSIS IN THE LIVING CELL IN AMOEBA PROTEUS

DURING the past few years *A. proteus* has been used in this laboratory as material for the study of cell division. It has proven excellent material, except that, due to the great number of granules, food vacuoles, etc., in the cell and the transparency of the nucleus at mitosis, direct observation of nuclear fission was impracticable. Recently the following method has been devised which permits mitosis to be quite readily followed in the living cell:

Two or three drops of hot .65 per cent. agar agar made up in saline[1] are placed on a thin microscope slide and allowed to set. Then a dividing amoeba, selected according to the criteria given by Chalkley and Daniel,[2] is placed on the agar in a small drop of culture fluid and immediatly covered with a cover glass. Fifteen mm square No. 1 is satisfactory. The cell is thus flattened but is not damaged, as the

[1] H. W. Chalkley, SCIENCE, 71: 442, 1930.
[2] H. W. Chalkley and George E. Daniel, *Physiol. Zool.*, 6: 592–619, 1933.

agar is soft enough to yield slightly and obviate damage. The nuclear changes during mitosis can then be observed under the microscope. A 2 mm oil immersion objective and 10^x compensating ocular are suitable. Under these conditions the following can be observed: The prophase nucleus appears as a spheroidal, usually slightly opalescent body, surrounded by a tenuous membrane and containing fine almost dust-like chromatin granules in active trembling motion. These granules gradually aggregate to form an annular plate. Generally this is formed in a plane normal to the surface of the slide. The nuclear membrane is still discernible at this stage. Following this the nucleus becomes flattened in the plane of the plate. Next there occurs a rapid radial shrinking of the plate, accompanied by disappearance of the membrane; almost simultaneously the plate splits in its plane, forming the daughter plates, which immediately separate and can be followed for a short time as they part. No spindle fibers can be seen, but their position is occupied by an opalescent or hyaline area into which no cytoplasmic granules intrude. By the time the daughter plates have separated for a distance of about their own diameter they show no granulation but appear as hyaline refractive disks. As a consequence of this, if it happens that division of the plate takes place in a plane other than that normal to the substrate this separation of the daughter plates is extremely hard to observe. As the plates reach the neighborhood of the cell membrane elongation of the cell begins and fine granulation is again visible in the plates and thin membranes can be seen at their surfaces. Before the cytoplasm of the two daughter cells has divided the new nuclei show definite granulation with active motion in their central portion. They possess also definite membranes with a layer of fine quiescent granulation just beneath.

The time relations of the mitotic process under these conditions are practically unchanged, as far as the nucleus is concerned; cytoplasmic fission, however, is greatly interfered with and in many cases is not completed.

At the completion of observation the amoebae are readily retrieved uninjured. If a drop of culture solution is placed with a pipette on the edge of the cover slip so that it flows beneath, the cover slip can be gently lifted from the agar without damaging the cell, which may then be transferred as desired by means of a pipette.

It is hoped that this simple method will be found of use in the study of mitosis in this and other related forms in which the granularity of the protoplasm has been a source of trouble.

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AN APPARATUS FOR COLORIMETRIC OXIDATION-REDUCTION STUDIES

THE apparatus consists of a B. and L. biological colorimeter modified so that the stationary side carries a metal cylindrical tube which fits closely over the plunger. It is kept in place on the metal at the top by 2 set screws. This tube has spring hooks at the bottom which serve to hold a detachable similar but shorter metal frame holding a cylindrical glass reaction container up to and in line with the plunger.

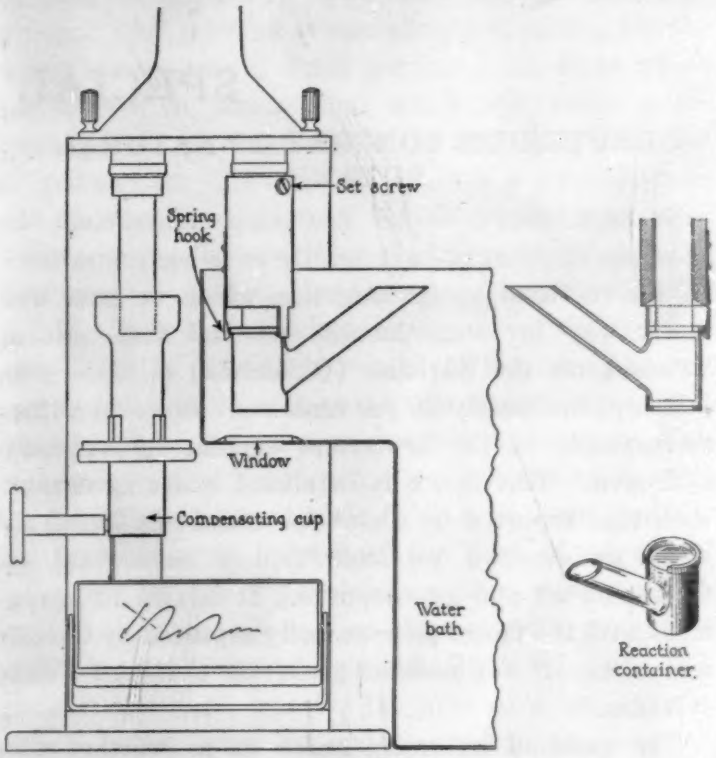

FIG. 1

The glass reaction container holds about 3 cc of fluid and is completely closed except for a side arm which comes off at an upward angle. Through this the reactants are added and the arrangements are made for exclusion of air (by evacuation or by an inert gas).

The reaction container is immersed into an extension and over a window set in the bottom of a specially designed constant temperature bath. The main body of the bath sits beside the colorimeter and does not block light reflected from the mirror which passes through the window.

The compensating cup (B. and L. 33.–27–31–01) may fulfil not only its usual function but it balances the water and glass window of the water bath.

The movable cup contains a standard solution of the dye which allows the fading curves to be followed as the reaction proceeds.

The flexibility of this simple compact arrangement with the fine control of end points makes the apparatus well adapted to dehydrogenation studies as well as to other reactions where the fading of an indicator is involved.

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COPYING MANUSCRIPTS ON MOTION PICTURE FILM

IN Dr. Seidell's article,[1] "Reforms in Chemical Publication (Documentation)," reference was made to the increased probability of the fulfilment of his aim if there was available suitable apparatus for photographing manuscripts on 16 mm film.

Such a device known as a "copying camera" using 35 mm film, 100 foot lengths, was developed at the Sterling Library, Yale University, some months ago by Messrs. F. G. Ludwig and L. H. Ott.

It proved so satisfactory that since that time they have built a number for use in various other institutions, such as the Library of Congress and the New York Public Library. The camera at the last-mentioned institution has been used for making permanent records of newspapers, which of course would survive only a short period of actual handling.

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SPECIAL ARTICLES

DEUTERIUM CONTENT OF NATURAL BUTANE

SEVERAL examples of deuterium enrichment in products of plant and animal life have been reported.[1] As the result of an investigation which we have had under way for some months we find that natural butane from the Burbank (Oklahoma) oil field contains approximately 30 per cent. more deuterium than corresponds to the deuterium content of ordinary hydrogen. This figure is in almost exact agreement with that reported by Dole[2] for Oklahoma kerosene, which indicates a probable typical enrichment of Oklahoma oil and gas deposits. It is also in agreement with the figure more recently reported by Greene and Voskuyl[3] for natural gas from northern Pennsylvania.

The question naturally arises as to whether this enrichment is typical of the deuterium distribution of the geological age in which these deposits were formed, or of the chemistry either of the growth or decay of the organic life responsible for the deposits. If the results obtained by Scott,[4] for free water associated with Pennsylvania petroleum, can be correlated properly with those for the Oklahoma deposits it would appear that the chemical explanation is the more plausible.

The butane which we employed was obtained by fractional distillation of natural gas condensate from the Burbank, Oklahoma, field and consisted of approximately 98 per cent. n-butane and 2 per cent. iso-butane.

The butane was burned at a quartz jet out of contact with the atmosphere in an excess of tank oxygen (prepared by the Linde process). The hot gases were passed through a quartz tube filled with copper oxide and heated to about 900° C., to insure complete oxidation. The steam was condensed in a Pyrex bulb surrounded with ice and water and provided with a condenser through which ice water was circulated. Two successive samples of about 100 cc each were collected. The deuterium content of the water of combustion was determined by means of the buoyancy balance.[5] Prior to the measurement final purification was effected by distillation from alkaline permanganate. The two 100 cc samples of the water were reduced to approximately 40 cc each by three successive distillations from Pyrex stills, with 10 cc discarded at the beginning and end of each distillation. The first two distillations were carried out in the presence of potassium permanganate and potassium hydroxide, the last without any added reagent.

The results are shown in Table I, in which the first line gives the results obtained with the water as it was collected from the still and the second line, the readings obtained after boiling out the samples to remove possible air or CO_2 contamination. The apparent change in Sample 1 is not regarded as significant. After the readings recorded in the second line the samples were mixed and refluxed over night with alkaline permanganate, in a Pyrex still. After two subsequent distillations, the second without permanganate, in which equal end portions were discarded as before the density was redetermined with the result shown in the third line of the table. The straight average of these five determinations was taken as the most reliable value.

TABLE I

BECKMANN READINGS AT WHICH THE FLOAT BALANCED IN THE PURIFIED WATER OF COMBUSTION

	Sample 1	Sample 2
Direct from still	3.310 ± 0.002°	3.310 ± 0.002°
After boiling out	3.315 ± 0.002	3.311 ± 0.002
After refluxing	3.313 ± 0.001	
Value chosen	3.312 ± 0.002	

[1] SCIENCE, 80: 2064, 70–72, 1934.
[1] Washburn and Smith, SCIENCE, 79: 188, 1934.
[2] Dole, *Jour. Chem. Physics*, 2: 337, 1934; *Jour. Am. Chem. Soc.*, 56: 999, 1934.
[3] Greene and Voskuyl, *Jour. Am. Chem. Soc.*, 56, 1649, 1934.
[4] Scott, SCIENCE, 79: 565, 1933.
[5] Lewis and MacDonald, *Jour. Chem. Physics*, 1: 341, 1933.

Two 100 cc samples of ordinary distilled water were then given a similar treatment, except for the final refluxing, which was omitted. The results are shown in Table II. The high values first obtained with

TABLE II

BECKMANN READINGS AT WHICH THE FLOAT BALANCED IN PURIFIED ORDINARY WATER

	Sample 1	Sample 2
Direct from still	3.289 ± 0.001°	3.282 ± 0.002°
After boiling out	3.289 ± 0.002	3.279 ± 0.002
Following one more distillation without $KMnO_4$	3.280 ± 0.001	3.280 ± 0.001
Value chosen	3.280 ± 0.002	

Sample 1 were apparently due to a little contamination by spray carried over in the first distillations, as evidenced by the result obtained after a fourth distillation. Accordingly, the first two readings on this sample were disregarded in obtaining the final average.

From these results we take ΔT, for the butane sample as compared with ordinary water, as 0.032 (± 0.003° C.) which is equivalent to 8.3 (± 0.7) ppm. excess in density. It is probable that a portion of this density increment is due to O^{18} enrichment in the tank oxygen which was used.[6, 7] If the heavy oxygen enrichment in our tank oxygen corresponded to that of Smith,[6] the density increase due to deuterium would then be 6.1 ppm. It is improbable that our oxygen would differ from this enough to be significant in the conclusions which we may draw.

On the basis of Bleakney and Gould's[8] work which fixes the deuterium/hydrogen ratio in ordinary water at 1 to 5,000, corresponding to a 21 ppm. influence on the density of ordinary water as compared with pure protium water, the 6 ppm. density increase in the water of combustion from butane corresponds to a 30 per cent. increase in deuterium.

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THE RESPONSE OF THE NORMAL GUINEA PIG TO THE ADMINISTRATION OF LIVER EXTRACTS[1]

NUMEROUS attempts have been made in the past to obtain a valid biological indicator of the hematopoietic activity of liver extracts which are therapeutically potent in pernicious anemia. As far as the writer is aware, this has not been accomplished. The phenomenon which is briefly described in the present communication consists in a rise in the percentage and in the absolute number of reticulocytes in the peripheral blood of a majority of normal guinea pigs, following the oral or parenteral administration to them of any therapeutically active liver extract. The capacity to react in this fashion to subsequent injections of such an extract is apparently maintained indefinitely. This reaction is exceedingly sensitive, for the minimum amount of fresh porcine liver, from which the extract is derived and which will evoke a response, is in the neighborhood of .6 mg per kilogram of guinea pig. This amount of liver is equivalent to one Guinea Pig Unit (G.P.U.) of hematopoietic activity; conversely, one hundred grams of fresh porcine liver may be said to contain approximately 164,000 G.P.U. That the reticulocyte response of the reactive guinea pig is intimately related to the true hematopoietic action of liver in pernicious anemia is rendered highly probable by numerous control experiments. The best evidence that the response is concerned solely with the hematopoietic materials in liver is furnished by the facts that the extract of the liver of a patient dying in a relapse of pernicious anemia, when assayed on guinea pigs, effected no demonstrable response, yielding an activity of less than 12 G.P.U. per 100 gm of fresh liver, whereas the liver of a non-anemic patient, when extracted and assayed in an identical fashion, showed an activity of approximately 164,000 G.P.U. per 100 gm of liver.

The response of the normal guinea pig to liver extracts may well be conditioned by the fact that such animals, both reactive as well as non-reactive ones, possess a richly megaloblastic bone marrow. Two sets of experimental results further offer evidence that the reactive guinea pig is endowed with a deficiency state that simulates the condition in pernicious anemia. In the first place, an extract of a reactive guinea pig's liver, when assayed on reactive animals, exhibited a hematopoietic activity of only 31,000 G.P.U., while the extract of a non-reactive animal's liver showed an activity of 164,000 G.P.U. Secondly, a mixture of Castle's intrinsic and extrinsic factors, when administered orally to guinea pigs in the form of normal human gastric juice and beef muscle, elicited a reticulocyte response differing in no way from that following the administration of therapeutically active liver extracts; while the extrinsic factor alone, or extrinsic

[6] Smith, *Jour. Chem. Physics*, 2: 298, 1934; SCIENCE, 79: 454, 1934.
[7] Klar and Krauss, *Naturwiss.*, 22: 119, 1934.
[8] Bleakney and Gould, *Phys. Rev.*, 44: 265, 1933.

[1] This investigation has been aided by grants from the Council on Pharmacy and Chemistry of the American Medical Association, and from the William W. Wellington Memorial Research Fund of the Harvard Medical School.

factor together with gastric juice inactivated by heat, provoked no response.

The foregoing facts partially explain why certain normal guinea pigs exhibit a hematopoietic reaction to the administration of liver extracts. This response is a tool which may prove its usefulness in the quantitative assay of the therapeutic potency of commercial liver extracts, and in various studies concerning the physiology of hematopoiesis and the pathogenesis of pernicious anemia.

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THE ANAEROBIC CONDITION OF SOILS IN POROUS PORCELAIN CONTAINERS

IT has generally been assumed that one of the virtues of porous clay pots for plant containers is that the material provides for the aeration of the soil through the walls of the pot. Jones[1] has demonstrated the fallacy of this assumption and his conclusions are strikingly supported by data obtained in some soil potential studies.

In an attempt to measure the potentials of soils in pots in the presence of growing plants it was thought advisable to protect one series of buried electrodes from contact with plant roots. The device used was to place ordinary bright platinum foil electrodes on glass stems into the same soil as that contained in the pot in porous porcelain capsules sealed at the top with picein.

These and the same type of electrodes without protection were imbedded in soil in one-gallon pots at a depth of about four inches. The soil in the pots was kept at a uniform moisture content of about 50 per cent. saturation. Potential measurements were made after the electrodes had been in place about a month. A saturated KCl-calomel electrode was placed in contact with the soil at the surface.

Considerable work with soil potentials has shown that aerated soils will give Eh values ranging from +.4 to +.7 volts, depending on the hydrogen ion concentration and the technique employed. Potentials below +.1 volts indicate an extreme anaerobic condition.

In the work under discussion the potentials listed in Table 1 were taken from a number of pots with different treatments.

It was anticipated that the electrodes exposed to plant roots would be negative to those enclosed in the porous porcelain capsules. The reverse was found to be true and the magnitude of the difference indicates an extreme anaerobic condition in the latter.

TABLE 1

POTENTIALS OF SOILS AT BARE AND PROTECTED ELECTRODES

Soil acidity	Potential (Eh) of electrode		Potential difference
	Bare	Protected	
pH	Volts	Volts	Volts
6.9	+.56	−.26	.82
6.8	+.60	−.14	.74
6.75	+.58	−.08	.66
4.6	+.72	−.11	.83
4.6	+.96	−.19	1.15
4.6	+.73	−.04	.77

The results indicate that oxygen does not dissolve and diffuse through the moisture in the walls of the capsule rapidly enough to supply the microorganisms in the soil within the capsule. They should be applicable to any static moisture film. The thickness of the film, the activity of microorganisms and the movement of the film either by convection or flow would govern the difference.

This evidence is a by-product of an investigation that was originally planned with another objective. It is one of many instances of the utility and versatility of the potentiometric method of studying soil properties.

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[1] Linus H. Jones, "Aeration of Soil in Plant Containers," *Florists Exchange and Horticultural Trade World*, 79: 11–39, 1932.

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